THE TECHNOLOGY ENABLING ELEMENT

COBALT IN BATTERIES

Cobalt is an essential element critical to many applications and now most widely used in lithium -ion batteries , such as NCM, LCO and NCA. These are utilised in portable devices, storage systems and electric vehicles, thereby it makes a crucial contribution in the field of renewable energies and sustainable development

✓ **Around 50% of the cobalt produced globally is found in rechargeable batteries**

WHY IS COBALT SUCH AN ESSENTIAL ELEMENT IN BATTERIES

Cobalt contributes decisively to the performance of rechargeable batteries

Cobalt's unique properties make it essential for the thermal stability of lithium batteries and the integrity of the cathode. Both are decisive factors for safety

Cobalt containing batteries are at the core of electric vehicles (EV), hybrid (HEV) and plug-in hybrid electric vehicles (PHEV)

Renewable energy storage systems use batteries that contain cobalt as one of its key elements

Smartphones, laptops and tablets rely on cobalt based batteries for functioning and better performance

Power tools used in a broad range of industrial activities operate with batteries containing cobalt

HOW IS COBALT USED IN RECHARGEABLE BATTERIES

Cobalt compounds

There are a number of cobalt compounds used in rechargeable batteries:

- ✓ Cobalt dihydroxide is used in the positive electrodes for nickel-based batteries (NiCd and NiMH)
- ✓ Lithiated cobalt oxides are used in positive electrodes for lithium-ion batteries (LCO, NCM and NCA)

Cobalt's key role

The most important use of cobalt in technology is in the cathode of rechargeable batteries:

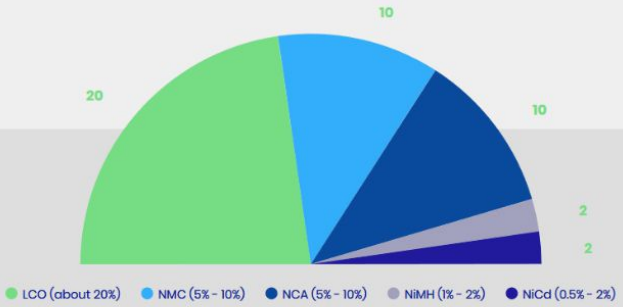
- ✓ During charge/discharge operations lithium-ions move from the anode to the cathode which is formed of cobalt oxide
- ✓ Cobalt is not only used in Lithium-ion based batteries (LCO, NCA and NCM) but also in Nickel based cells (NiCd and NiMH)

Cobalt as key component

There are a wide range of rechargeable batteries which contain cobalt as one of their main components:

- ✓ **LCO** (Lithium Cobalt Oxide) batteries can be found in portable devices such as laptops, smartphones, tables and digital cameras
- ✓ **NCM** (Lithium Nickel Cobalt Manganese Oxide) batteries are mainly used in electric vehicles and cutting tools
- ✓ **NCA** (Lithium Nickel Cobalt Aluminium Oxide) batteries are also preferred for electric vehicles
- ✓ **NiMH** (Nickel Metal Hydride) batteries are often found in some hybrid vehicles and power tools
- ✓ **NiCd** (Nickel Cadmium) batteries are mainly used in industrial batteries and power tools

COBALT USAGE IN RECHARGEABLE BATTERIES



✓ **The important role cobalt plays in cathode technology is among the reasons why it has been classified as a 'critical raw material' by the EU and 'strategic' by the USA**

WHAT ARE COBALT'S MAIN CONTRIBUTIONS TO BATTERIES

STABILITY

The use of cobalt confers thermal stability and resistance to the structure and functioning of the rechargeable battery in the process of charging and discharging due to the unique properties of the cobalt ions

HIGH ENERGY DENSITY

Cobalt plays a decisive role to achieve high energy density materials (Li-ion and Ni-MH/Ni-Cd batteries)

HOW DOES COBALT CONTRIBUTE TO A SUSTAINABLE PLANET

- Cobalt and cobalt compounds are all used in a wide range of battery applications including:
  - Portable devices: mobile phones, laptops, tablets, cutting tools
  - E-mobility: electric vehicles and hybrid electric vehicles, electric trains, electric bikes
  - Stationary: renewable energy power stations, home storage, electrical grid
- Rechargeable batteries enable a more extensive use of renewable energies

✓ **The ability to reuse rechargeable batteries in a second life, where cobalt plays a decisive role, along with increasing recycling rates, contributes towards a green, circular economy**

Sources: Cobalt Institute, ReCharge

Cobalt Institute

www.cobaltinstitute.org

Promoting the sustainable and responsible use of cobalt in all forms